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New Virus Theory

There is perhaps no more entrancing field in scientific inquiry than the nature of the principle responsible for that heterogeneous group of plant and animal maladies : the virus diseases. Tobacco mosaic was the first of these diseases in either the plant or animal kingdom to receive investigation, and it is now 50 years since Mayer showed experimentally that this condition was of an infectious character. The researches of Iwanowski, Beyerinck and others in the latter part of last century led to the belief that the causal agent was an organism of extremely minute size, or a contagious living fluid, but the former idea has been widely accepted as a working hypothesis in preference to the theories of other workers who variously have claimed that viruses are enzymic, bacterial, or protozoal in nature. Allard's demonstration in 1914 of mosaic disease transmission by aphids tended to strengthen the view that plant viruses were in reality sub-microscopic organisms. But in view of the unique properties of this

tobacco virus : filterability and infectiousness at a dilution of up to 1-1,000,000, unusual powers of resistance to heat and chemical action, retention of infectious properties after long periods of storage, and its refactory nature, certain investigators have long since abandoned the theory that virus diseases are animate in origin and have directed their studies toward demonstrating that a chemical phenomenon is involved.

In this connection a most revolutionary contribution to the subject has recently been made by Dr. W. M. Stanley, of the Rockefeller Institute of Medical Research, New Jersey, who announces (in "Phytopathology," April, 1936) that he has isolated a crystalline protein possessing the properties of tobacco mosaic virus. The method of isolation was relatively simple, depending as it did on purification of the extracted juice by filtration through various grades of celite and precipitation of the protein by ammonium sulphate. The investigation demonstrated that the protein substance was many times more active than ordinary expressed juice of diseased tissues, was present in affected plants in relatively large amounts—approximately two milligrams per m.l. of extracted juice, and was infectious at a dilution of one in a billion. By precipitin tests it was also found that the protein did not occur in healthy plants.

In acknowledging the revolutionary nature of his contribution, Dr. Stanley points out that when the results are examined in the light of recent developments in protein chemistry, they are not altogether surprising. He alludes to the isolation by another investigator of a crystalline protein, trypsinogen, which is characterised by its inactivity but which, on addition of trypsin, is actually converted into trypsin—an active hydrolytic agent (an instance of autocatalysis), and adds that it is conceivable that the introduction of a small amount of virus protein into a plant activates some unstable or transient form of protein resulting in the formation in large quantities of the disease-producing agent, and the development of pathological effects. Should the precursor of the virus protein exist in some plants and not in others, host specificity of viruses could thus be explained, while the occurrence of strains might be interpreted on a chemical basis as resulting from changes in the protein molecule giving rise to similar proteins or isomers.

Dr. Stanley's work appears to have solved the much debated question as to whether viruses are living or non-living agents. Doubtless there are many who still prefer to adopt a silent attitude on what appears to be an epoch-making contribution in science, remembering that previous important claims by other virus specialists have not borne the test of time. But, as pointed out by Mr. C. J. Magee in his address on this subject at a recent meeting of the N.S.W.

Branch of the A.I.A.S., Dr. Stanley's attack on the problem involved procedure of a most careful and critical nature, and his technique in methods demanding intimate acquaintance with knowledge of higher chemistry appears to be faultless. It is now some little time since the announcement of the discovery was originally published in "Nature" (1935) and it is perhaps significant that so far nothing has appeared in technical literature which is in any way subversive of the new theory.

The Dairying Industry in Western Australia

SOME NOTES ON ITS DEVELOPMENT

By G. K. Baron-Hay, B.Sc.(Agric.)

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The development of the dairying industry in Western Australia is of interest not only to administrators in dairy science itself but to those in agriculture generally, as, owing to special local conditions, the two are rather more closely associated than is the case in other States; also, owing to its comparative youth in Western Australia, it has been possible to apply to the dairying industry those lessons which have been learnt from the experience of more matured countries or States.

For convenience, the development of the industry in Western Australia may be divided into three distinct periods, namely:—

(1) The Stationary Period, 1895-1919.

(2) The Period of Growth and Development, 1919-1933.

(3) The Period of Consolidation, 1934 onwards.

The stationary period is recognised by a continual and increasing importation of dairy products, principally butter from the eastern States and, at irregular periods, from overseas. This had been brought about by the great influx of population following on the discovery and the working of the gold mining areas in the north and east of the State, particularly during the years 1894-1899.

From time to time, those in power called attention to the necessity for developing the dairying industry which was being neglected owing to the demand for other agricultural produce—such as chaff, wheat, oats, barley, etc.—for the goldfields area; this produce was more costly than butter to import owing to heavy freights in comparison with their ton value. Moreover, it was recognised at an early date that the clearing of land suitable for the growing of wheat, oats, etc., and enjoying a winter rainfall of 18 to 25 inches was considerably cheaper than the clearing of the more heavily timbered country which enjoyed a higher precipitation and which, therefore, was naturally more suited to the production of milk.

In spite of these efforts, it is remarkable that until 1919 the majority of the dairy cattle in the State were to be found in the low rainfall districts stretching eastward from a line joining Perth to Albany, four butter factories being erected in this area whilst in the country more suited to dairy farming only two factories were to be found.

The following details indicate the position in 1919-20 which obtained at the commencement of the *Period of Growth,* which was a direct result of the repatriation of soldiers returning to Australia from the war:—

Number of Cows	42,563
Yield per Cow	226 galls. Milk 90 lb. Butter Fat
Acres of Sown Pasture	16,672
Acres of Pasture per Cow	.39
Importation of Butter and Cheese	7,750,000 lb.
Value, including Condensed Milk	£930,000 (approx.)

The picture presented by these figures is anything but a cheering one. The low yield per cow rendered dairy farming quite unprofitable except at an uneconomically high price which, as a matter of fact, happened to be ruling at this period, namely, 2/3d. per lb. for butter fat. Moreover, the area of pasture available per cow unit was only .39 acres, whilst investigations over the last 4 years have shown that, even with the improvement which has taken place in pastures during the last 16 years, at least 4½ acres per cow unit is required, a cow unit being regarded as a milking cow with the other stock usually associated with her in the form of heifers, bulls and horses, etc.

It appears from these figures that at this period there were two very weak points in the industry from an economic aspect, viz.:

(1) inadequate provision for feeding the cow, and

(2) the low production of the cow.

When the decision was given by the State Government in 1919 that the heavily timbered areas of the State suitable for dairy farming were to be de-

veloped, it was essential that a sound policy for tackling these two problems should be evolved and steadfastly pursued.

At this period and particularly from 1921 onwards, investigations by the Department showed the wonderful response which subterranean clover made to an annual top-dressing of superphosphate, the average increase being from 200 to 300 per cent. over that portion receiving no fertiliser. An intensive campaign throughout the State was launched to induce farmers to look upon this fertiliser as a necessity for the production of pasture just as much as in the production of a cereal crop. Within a short time, practically all farmers throughout the State were using this fertiliser annually.

The special character of subterranean clover, being an annual, combined with the seasonal rainfall—its incidence being from May to November—introduced special problems in regard to the working out of a feeding programme. Until three years ago the great bulk of pasture consisted of annual plants, principally subterranean clover. This resulted in (a) a period of slow growth immediately following germination in the autumn (May); (b) a period of rapid and rank growth during the spring; and (c) a period of rapid maturity of pasture plants, then death, only dry feed being available thereafter.

The special problems introduced by this sequence of pasture plants were—(1) a serious lack of mineral matter, particularly phosphoric acid, in the pasture except during the comparatively short growing period; (2) a serious lack of protein in the fodder during the dry months of the year; and (3) no laxative fodder available to assist in summer production.

The lack of mineral matter was overcome by the feeding of di-calcic phosphatic lick to all stock from the time the pasture reached maturity until ample green fodder was available again. The lack of protein during the summer months was more difficult to combat, but it was found that by cutting excess clover during the flush period and conserving this as silage, stock could be maintained in health and, if necessary, in profit during the dry months.

During the last four years summer production has been increased by the development of irrigation schemes of which there are three, embracing approximately 30,000 acres of irrigated land.

It has been stated that the necessity of applying superphosphate annually is uneconomic in comparison with other regions of Australia where no fertiliser is essential. This, however, is more than offset by the cheap capital cost of the land and the certainty with which the winter rainfall appears—no drought yet being known throughout the south-west dairying districts—and the production of butter fat per acre is comparable with that on unirrigated areas in other States, averaging 56 lb. per acre, although individual farmers have obtained three times this amount.

Coincident with the possibilities of subterranean clover being recognised,

the policy of clearing with a view to pasture production was initiated by the Government in the early twenties, the effect of which is shown in the following figures, there being now approximately four acres of pasture to each cow instead of .39 acres 15 years ago.

INCREASE IN PASTURE PRODUCTION

Year	Acres.
1919	14,158
1925	60,257
1930	339,371
1935	461,322

The second factor—that of improving the production of the dairy cow—was more difficult. Within three years, approximately 17,000 new dairy farms were opened up in virgin country in the south-west portion of the State, and practically all the owners of these farms were inexperienced in dairy husbandry, being selected from various avocations in Great Britain. The problem of stocking these farms was considerable, and it was found necessary to import several thousand dairy heifers from New South Wales.

The view was taken that the only way whereby the production of large numbers of dairy stock could be economically increased, apart from the provision of more nutritious fodder, was by relying on the breeding of higher quality heifers, using pure bred dairy sires, if possible with a production backing.

Moreover, it was considered unwise to allow inexperienced farmers to select the breed of sire which they would use, and the State was divided into zones, only one breed of bull being supplied by the Government in each zone. Experienced dairy farmers who purchased their own stock were not affected by this policy. Some 600 pure bred bulls *ex* tested dams—many of them being imported—were purchased by the Government, and the result was that in a comparatively short time the dominant breed of cattle in any district became that of the zone.

Two years ago, all these producers became ordinary farmers and are now able to pursue their own breeding policy, but in the majority of instances the principle of "grading up" to the one breed has been instilled into them, with the result that no change is being made.

Coincident with this policy, a "Dairy Cattle Improvement Act" was introduced in 1924, whereby all dairy sires in the State were required to be registered annually at the Department of Agriculture which had the power to stipulate that certain grade bulls, after inspection, were of undesirable type and must be slaughtered.

The following table sets out the increase in the percentage of pure bred bulls during the 10 years in which the Act has been enforced, and also the improvement in the average production of cows in the State. It is significant that the curve showing the increase in the percentage of dairy sires follows closely that of the increase in production of dairy cows.

INCREASED PRODUCTION COINCIDES WITH THE INCREASE IN NUMBER OF PURE BRED SIRES

Year	Pure Bred Sires %	Average Production Milk per Cow (gallons)
1925	23	218
1928	35	254
1931	50	322
1934	56	342

These figures are for the whole State including wheat and sheep areas, the average production of cows in the dairy districts proper being considerably in excess of these figures, and, from the result of investigations for the last four years, being estimated to be at least 450 gallons per cow.

It may be thought that, following on the recognition of the value of tested stock as indicated above, a system of grade herd recording would have been instituted as soon as possible. It was considered, however, that all pure bred cows should be tested if possible, as these formed a nucleus from which the supply of dairy sires could be obtained, and Pure Breeds Herd Recording under the official Australian rules was instituted in 1918. Grade herd recording, however, was not generally instituted until 1933, because previous to this time the shortage of dairy stock was acute in view of the rapidly increasing area of pasture available which was able to support more than the natural increase. This is indicated by the rapid increase in milch cows during this period, namely, from 42,563 in 1919-20 to 124,000 in 1934. As Grade herd recording would necessarily involve the culling of herds, the official view was taken that all dairy females, if mated with pure bred bulls *ex* tested dams, were the potential breeders of higher quality heifers.

The results from grade herd recording over the last three years indicate that the average production of cows throughout the dairying districts in Western Australia is rapidly increasing and is comparable with that in the dairying districts in other portions of Australia.

RESULTS FROM GRADE HERD RECORDING

Year	No. of Cows	Milk (Gals.)	Butter Fat (lb.)
1933-34	4,038	415	180.6
1934-35	4,088	456	208
* 1935-36	4,500	490	220

* Incomplete

With the institution of grade herd recording there commences the third period in the development of the industry in Western Australia, namely, the "Period of Consolidation," during which the policy is to endeavour to reduce

the cost of production of dairy produce by means of improved pasture management leading to increased carrying capacity, improved production per cow, and particularly by the increase in production during the summer months, December to April, in those districts suitable for this purpose.

A combination of the factors briefly outlined above has caused a phenomenal increase in the production of dairy produce, particularly butter and—during the last three years—cheese, as is shown in the following table:—

INCREASE IN PRODUCTION OF BUTTER AND CHEESE (lb.)

Year	Butter	Cheese
1920-21	2,212,311	Negligible
1924-25	2,962,630	"
1929-30	6,179,482	"
1934-35	13,000,000	624,345

While these total productions may seem small in comparison with those of more developed States, the increase is rapid and, as not more than one-tenth of the area considered specially suitable for dairy farming has yet been touched, it is anticipated that this rapid increase will continue.

Owing to lack of space, no mention has been made of problems in connection with the manufacture of dairy produce, many of which are peculiar to Western Australia but are gradually being solved by investigations carried out by technical officers of the Department of Agriculture and manufacturing companies.

Cereal Rust Problems in Australia

Some scattered paragraphs from the Presidential Address delivered at the Linnean Society of New South Wales by Dr. W. L. Waterhouse on 25th March, 1936. (Literature citation list omitted)*

LOSSES FROM WHEAT RUST

Turning to rust losses which have occurred since the "Rust in Wheat Conferences," we find estimates of which many are based upon carefully compiled figures. Guthrie (1914) states that the 1899 loss from rust amounted to £1,500,000. McAlpine (1905) states that 1903 was a bad year; Mr. A. H. E. McDonald, Director of Agriculture in New South Wales, estimated the losses in this State that year to have been three million bushels, worth more than £400,000. The same authority calculated that in the 1916 epidemic in New South Wales, rust losses exceeded £2,000,000.

* Proc. Linn. Soc. N.S.W., 61: V—XXXVIII, 1936.

In the year 1925, Mr. McDonald states that the general loss through rust was 5% of 60 million bushels, valued at 6s. 2d. per bushel, a total loss of £925,000.

The rust problem is clearly one of considerable magnitude so far as New South Wales is concerned. Taking only the figures set down for the years 1916, 1920, 1925, 1930 and 1934, and omitting altogether the other records of serious damage not here assessed in terms of money (but unquestionably great), during the past 20 years the average annual loss in New South Wales has amounted to a quarter of a million pounds. This figure may seem surprising on account of the apparent insignificance of rust in the crops in some seasons.

ORIGIN OF RUST IN AUSTRALIA

The question is often asked, "How did rust come to Australia?" We know only too well that our list of plant diseases has multiplied alarmingly in recent years, and in some cases we know how these dread pathogens have reached our shores. But in the case of rust, we can only speculate upon the source of the original inoculum.

The cereal rust fungi are not seed-borne. The original "seed" wheat brought to Australia by the early pioneers doubtless introduced smuts, but some other source must be sought for the rusts. As far as stem rust is concerned, barberries are not indigenous and were not brought to Australia until much later in the history of the settlement than the recorded outbreaks of rust. Hooker (1859) refers to *Barbarea vulgaris* being present in that year in Tasmania. In 1864, the Third Annual Report of the Acclimatisation Society of N.S.W. refers to *Berberis* sp. amongst the plants alive in the Botanic Gardens. No close relative of the barberry is a native, and no Australian plant is known to harbour the aecidial stage of the fungus, so that even if teleutospores were brought by the early settlers they could not have initiated the disease.

Air-borne uredospores from cereal crops in India or elsewhere may have been responsible for the first infections of the early wheat crops. It is known that rust spores have been carried thousands of miles by wind, frequently associated with atmospheric dust. No such determinations have been made in Australia, but many observations are reported by workers in other countries.

One of our native perennial grasses, *Agropyron scabrum* Beauv., a near relative of wheat and a widespread plant in the south-eastern portion of the continent, has lately come up for special study as a host of wheat stem rust (Waterhouse, 1934, 1935). In regard to the origin of black stem rust of wheat, the possibility must be borne in mind of the rust having been present on this grass prior to the arrival of the early settlers. If this was so, then when wheat was grown the rust might be expected to spread to it from the grass host.

CHANGE IN RUST FLORA

Since the commencement of the studies in 1921, and carrying the work up to 1st January, 1936, eight naturally occurring forms of *P. graminis Tritici* have been determined in Australia.

In the aggregate, form 34 has been present in 80% of the cases examined. It was unknown prior to November, 1925. In November, 1927, it dominated the situation to the almost entire exclusion of the other six forms.

To account satisfactorily for the change in the rust flora, leading to the dominance of form 34, is difficult. It is improbable that it arose from an aecidial infection of the barberry. It may have originated as a mutation, but one would scarcely have expected it to supersede the other forms so widely and so rapidly. If viable uredospores can be carried across the Indian Ocean in air currents, it may have come from India.

Independent evidence supports this finding of a change in the rust flora at about this time. Inquiries from several prominent wheat-growers in New South Wales have elicited the information that they have noticed that "since about 1927" varieties which formerly showed a degree of rust resistance have become completely susceptible to attack. Now, practically all the commercial varieties of Australian wheats are susceptible to form 34. With its advent, "Canberra," "Yandilla King," and other sorts were attacked. Furthermore, it is noticeable in controlled plant-house work that this form produces uredo pustules on susceptible wheats in a much shorter time than any of the other forms that have been studied. This of course means increased virulence. One's own observations confirm the reports that crops in the field have been more heavily attacked during the past decade than formerly.

This change in the physiologic forms has profoundly affected the breeding problem, and further emphasises the vital need for studying the physiologic specialisation exhibited by a pathogen if varieties resistant to it are to be produced. The very great effect it had upon the breeding work for rust resistance has already been recorded (Waterhouse, 1930). By controlled work in the plant house and the field, agronomic types resistant to all the six forms were synthesised from crosses between two wheats, one carrying resistance to the first group of forms, the other having resistance to the second group. In 1927 their resistance "broke down." This was simply a manifestation of the newly arrived form 34, to which each of the parents used in the cross was completely susceptible.

BARBERRY ERADICATION

There is a clear case for eradication of barberries throughout Australia, following upon the good example set by so many other countries. It is probable

that natural infection is uncommon, but there is proof that, at least occasionally, Australian conditions make it possible for infection to take place. From only one such infection there is always the possibility of new forms arising. These may completely upset the work of breeding for rust resistance. The legislative action recently taken which makes barberry destruction compulsory is to be highly commended, and should be loyally carried out. The only regret is that eradication was not commenced earlier, following upon the evidence presented 15 years ago (Waterhouse, 1921), that stem rust in Australia had not lost its ability to infect the barberry.

Recent Developments in Genetics and Plant Breeding

By I. F. Phipps,

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Progress in genetics has, in the immediate past, been intimately related to advances in cytology. At the present time three concepts or discoveries in cytology are contributing largely to genetic thought and investigation: namely, (1) the interpretation of the nature of chromosome pairing and segmental interchange (genetical crossing-over) presented by Darlington and his co-workers; (2) the spectacular discovery that the salivary gland chromosomes of *Drosophila* are of immense size and are composed of bands and lines of deeply staining chromatic material. Students of *Drosophila* genetics can now identify, cytologically, any point on a chomosome; and chromosome changes such as deletions, translocations and inversions can be readily detected; (3) cytological studies on polyploid species and the interpretation of chromosome behaviour in interspecific or intergeneric plant hybrids have solved many difficult problems in plant genetics, and also form the basis of modern plant breeding.

GENETICS

The nature, action and physiology of the unit of inheritance, the gene, are still baffling problems. Some progress has been made by a new technique whereby the method and time of action of genes for eye colour in *Drosophila* are determined by transplantation of larval optic discs of the various eye colour types into larvae of other eye colour types. Also the number of genes vital to the normal life of *Drosophila melanogaster* has been estimated, by an ingenious method based on the production of lethal genes by X-ray treatment, to be not less than 14,380, and that the average size of the gene is 1×10^{-6} cms.

* Summary of an address delivered to the South Australian branch of the Australian Institute of Agricultural Science on 25th June, 1936.

In plants, great advances of special interest to plant breeders have been made in the genetics and cytology of polyploids. New polyploids and frequently new species have been created experimentally by X-ray treatment (tobacco), extremes of temperature (maize and wheat), decapitation (tomato), and the chance production of multiple chromosome sets either in somatic tissue or in germ cells. It has been shown that polyploids may arise by failure of cell wall formation in somatic tissue of normal plants; by doubling of the chromosome number in somatic tissue after fertilisation; by hybridisation between species with different chromosome numbers; and by the union of gametes containing the unreduced number of chromosomes especially in sterile, interspecific and intergeneric hybrids.

A successful triple hybrid between the three genera *Zea, Tripsacum* and *Euchlaena* has been reported.

Inheritance in *Oenothera* has been studied since genetics began 36 years ago; but only recently has a clear and uniform picture of inheritance and chromosome behaviour in this genus been presented. It is now known that the rings of chromosomes found during meiosis are the result of reciprocal exchanges between unlike chromosomes; that the presence of two or more zygotic lethals in a ring produces a type, e.g., *Oenothera Lamarckiana,* which although a complex hybrid, breeds relatively true to type. Further, the high rate of mutation, studied so extensively in this species by De Vries, is due in part, to crossing over.

The widespread occurrence of polyploid species in plants (with the exception of Cyperaceae and Orchidaceae) and the experimental production of new polyploid species indicate that this phenomenon of chromosome doubling, especially in sterile hybrids, has been a fertile source for the origin of plant species. In animals, on the other hand, polyploidy is rare. Here inversion, translocation and related chromosome changes (which occur also in plants, e.g., in *Oenothera, Zea* and *Pisum*) are of importance in the development of new species.

PLANT BREEDING

A new outlook, based essentially on recent developments in genetics and cytology and which may be stated briefly as the introduction of new genes—new combinations of characters—into our cultivated plants, is evident in plant breeding. This objective is being achieved by crossing cultivated varieties of horticultural and crop plants with wild growing forms, and above all by the production of economically valuable polyploids from hybrids between cultivated plants and related species and genera. The method has been applied successfully to crops propagated asexually such as horticultural crops, small fruits, sugar cane and potatoes. A new genus, *Triticale,* produced from a cross between wheat and rye promises to be of economic importance. Russian plant

breeders under the direction of N. I. Vavilov have assumed the leadership in this new aspect of plant breeding. They have searched the world for valuable varieties and related species and genera of practically all cultivated plants and are incorporating, by cross-breeding, the desirable characters into their varieties. Success has attended these efforts. The possibility of obtaining hardy, disease resistant perennial wheats from successful hybrids between the perennial grass *Agropyron* and wheat has also been announced.

Some Principles of Statistics and Their Application to Agricultural Experiments – III.

By
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REGRESSION LINES AND CORRELATION.

In dealing with agricultural problems, the experimental worker often finds that he must consider the simultaneous variation of a number of different factors relating to the crop or stock he is testing. For instance, in making a comparison between several varieties of a crop, some of which require to be sown late, and some early, the initial stand may be affected by the weather conditions at the time of sowing. If the conditions are very extreme for some varieties, it will perhaps be necessary to take this into consideration in making a comparison of yielding abilities. If for each variety a satisfactory expression could be found for the relation between number of plants and yield, then all the varieties could be compared on the basis of the same number of plants. In feeding experiments with animals, one of the greatest difficulties is the inability to obtain animals that are all the same weight and exactly similar in condition. This trouble is partly overcome by a proper allotment of the animals to the different groups being tested. For instance, if five treatments are to be compared, the total number of animals must be a multiple of five. They can be divided into the best five, the second best five, and so on. One animal from each five will then be chosen at random for each treatment. This method ensures that, as far as possible, the groups of animals under each treatment are similar. Proper allowance for major differences between the first five animals and the second five animals, and so on, can be made in the

subsequent analysis of the results. The plan is equivalent to the method of randomized blocks in field experiments. When the animals are very uneven, this method is not entirely adequate. A more satisfactory approach may be to find a relation between the initial weight and subsequent behaviour and then correct the results for the initial differences in weight.

In such problems as these, the required relationship is generally not known beforehand, and the observations themselves must be used to determine it. The most usual way of obtaining a relation between two variable quantities from a set of pairs of observations of them is that known as the " method of least squares ".

If y represents one of the variables, and x the other, then a relationship is assumed of the form $y=f(x)$. The type of the expression for $f(x)$ can be chosen arbitrarily, and an indication of a suitable form is generally obtained by a rough examination of the data. If the observed values of x and y are plotted and are found to lie approximately on a straight line, or if the mean values of y corresponding to given values of x lie on a straight line, then an equation of the form $y=a+bx$ will be assumed ; when the graph is curved, an equation of the type $y=a+bx+cx^2$ may be suitable, or perhaps $y=a+bx+c \log x$. After the type of function has been decided, it then remains to find the exact expression of that form which will fit the data best. Using the method of least squares as the criterion for best fit, the procedure is to choose the constants a, b, c of the equation in such a way that the sum of the squares of the differences between the observed values of y and those calculated by the formula for the corresponding values of x shall be the smallest possible for that type of expression. By means of the Calculus, equations are found for determining the values of the constants which satisfy this minimum condition. Although theoretically any type of equation can be fitted to the data by this means, it is only for a few simple expressions that the constants can be easily found. The three quoted above are amongst these. The simplest of all is the linear form $y=a+bx$, and consequently this has the widest application in experimental work generally.

Suppose (x_1y_1) (x_2y_2) . . . (x_n, y_n) are n observed pairs of values of the variable quantities, to which we want to fit an equation of the form $y=a+bx$.

The sum of squares

$$(y_1-a-bx_1)^2+(y_2-a-bx_2)^2+ \ . \ . \ . \ (y_n-a-bx_n)^2$$

would have different values according to the values we took for a and b, and we want to choose a and b so that this quantity will be as small as possible. The conditions for this are, according to the calculus,

$$S(y)=na+bS(x)$$
$$S(xy)=aS(x)+bS(x^2),$$

where the summation sign indicates addition of all the observed values. These two equations are called the normal equations, and the values of a and b can

be determined from them. The solutions are found to be :

$$a=\frac{S(y)\ S(x^2)-S(xy)\ S(x)}{n\ S(x^2)-\{S(x)\}^2}$$

$$b=\frac{n\ S(xy)-S(x)\ S(y)}{n\ S(x^2)-\{S(x)\}^2}$$

This is the form in which they are probably most easily calculated.

The expression for b reduces to

$$b=\frac{S(xy)-n\ \bar{x}\ \bar{y}}{S(x^2)-n\ \bar{x}^2}$$

$$\text{or } b=\frac{S(x-\bar{x})(y-\bar{y})}{S(x-\bar{x})^2}$$

The straight line whose equation, $y=a+bx$, is found in this way is called the regression line of y on x, the equation is called the regression equation, and b is known as the linear regression coefficient of y on x.

If an equation of the form $x=a'+b'y$ had been found by making $S(x-a'-b'y)^2$ a minimum, it would represent a slightly different line from the regression of y on x. It is known as the regression line of x on y.

In some problems it is not the equation relating the two variables that is required, but an actual numerical measure of the amount of association between them. Then the quantity is calculated which is known as the correlation coefficient. The formula for it is

$$r=\frac{S(x-\bar{x})\ (y-\bar{y})}{\sqrt{S(x-\bar{x})^2\ S(y-\bar{y})^2}},$$

which can be reduced to

$$r=\frac{S(xy)-n\ \bar{x}\ \bar{y}}{\sqrt{(Sx^2-n\bar{x}^2)\ (Sy^2-n\bar{y}^2)}}$$

The value of r is zero when there is no association at all between the values of x and y, positive when the values of y tend to increase as the values of x increase, and negative when the values of y decrease as x increases. On account of the form of the expression, r cannot have a value which is numerically greater than 1.

The correlation coefficient is closely connected with the regression coefficient b, as can be seen by a comparison of their formulæ. If, when the points corresponding to the given values of x and y are plotted, they are found to be exactly on a straight line, then r is numerically equal to 1. It is positive or negative according to whether x and y increase together or not. Also, when the observed points lie exactly on a straight line, the two regression lines must necessarily coincide.

Even when there is no real association between the two variable quantities,

so that if enough observations could be taken the correlation coefficient and the regression coefficients found would be zero, the values of r, b and b' calculated from a small sample of pairs of values of x and y would probably not be actually equal to nought. It is important to be able to test whether a value found by experiment is likely to indicate a real relationship, or whether it has arisen by pure chance. For instance, it may be found that over a period of fifteen years at some station a small positive correlation existed between the yield of wheat and the rainfall during a particular part of the growing season. A great many causes can contribute to the increase or decrease of yield, and it would be useful to know whether the observed correlation represented a genuine association. In the illustrations cited earlier, it would not be worth while making a correction for the initial conditions if the correlations obtained were not significant.

In order to test the significance of a mean, or the difference between several means, of observations on a single variable quantity, it was assumed that if enough observations could be taken, they would be distributed in a normal frequency distribution. Similarly in making tests of the significance of the linear regression coefficient, and the correlation coefficient, it is necessary to assume a special form for the hypothetical distribution of pairs of values of x and y. This hypothetical distribution is such that, if the range of values of x were divided into a series of small class intervals, the distribution of values of y corresponding to the values of x in any particular class would be a normal distribution. Similarly, all the values of x corresponding to a particular value of y would have a normal distribution. The equation to the frequency distribution of pairs of values of x and y involves the hypothetical means and standard deviations of x and y, and also a quantity, usually designated by ρ. This is the hypothetical value of the correlation coefficient, which we should obtain if the number of pairs of observations was very great. When there is any correlation between x and y the variation in the values of y corresponding to some particular value of x is less than the variation in values of y as a whole. This is expressed mathematically by the fact that if σ_y^2 be the variance of values of y generally, then $\sigma_y^2 (1-\rho^2)$ can be shown to be the variance of values of y corresponding to any particular value of x.

In the hypothetical distribution, the regression coefficient of y on x is $\rho\frac{\sigma_y}{\sigma_x}$, and the regression coefficient of x on y is $\rho\frac{\sigma_x}{\sigma_y}$. The values of r, b and b^1 which are calculated from a sample are estimates of the hypothetical population values of the correlation coefficient and regression coefficients.

The test of significance of a correlation coefficient or a regression coefficient is a test of the probability of getting by chance such a value as the one observed, when the true correlation is zero. The frequency distribution of observed correlations was discovered by Professor Fisher. Before its discovery, only

a very rough test could be made of the significance of correlations, by assuming that r had a normal frequency distribution wit standard deviation $\frac{(1-r^2)}{\sqrt{n-1}}$. This is approximately true when the number of pairs of observations is very great, and the correlation fairly small. Since these conditions are seldom realized, the test is not a sound one to use in experimental work.

An exact test can be made by calculating

$$t=\frac{r}{\sqrt{1-r^2}}\ \sqrt{n-2}$$

where n is the number of pairs of observations, using the same table as was used for Student's t-test, with $n-2$ as the number of degrees of freedom.

The significance of the regression coefficient is tested by calculating

$$t=\frac{b\sqrt{S(x-\bar{x})^2}\ \sqrt{n-2}}{\sqrt{S(y-a-bx)^2}}$$

and looking up the t-table with $n-2$ as the number of degrees of freedom. The values of t calculated from r and from b are identical; significance of either of the quantities r or b implies the significance of the other also.

When more than two factors are concerned and a linear relation is to be determined between them, the same steps are followed. If there are three variables, y, x, and x', an equation is assumed of the form $y=a+bx+cx'$, and the constants are found by the method of least squares, as before. There will be three normal equations instead of two. The correlations between any two of the variables can be estimated in the ordinary way, without reference to the observations on the third variable. When the three correlations between the different pairs are known, other quantities, called partial correlations, can be found. The partial correlation between y and x when x^1 is eliminated, is the correlation that would exist between y and x if x^1 were kept constant. Partial correlations are easily calculated from the direct ones by means of a simple formula, and tests of significance can be made on them in the ordinary way. They are of value in many agricultural problems. For example, the individual increase in weight of a group of animals would be related both to their ages and to the amount of food each had consumed. It might be interesting to know the correlation that would exist between increase in weight and quantity of food eaten, if the animals were all of the same age. This could be found by the method of partial correlations. Correlation between crop yield and any one meteorological factor, with the effect of other factors eliminated, can be found by this means.

When a correction for some uncontrolled factor is to be made in the analysis of an experiment, there is often not enough data to give more than a very rough idea of the most suitable curve to fit. In such a case it is often

sufficient to assume a linear relation, and find the linear regression coefficient, and the correlation coefficient. The process is illustrated by an analysis of data on the root weights of wheat plants in a pot experiment. The same number of seeds were sown in each pot, but the germination was unsatisfactory, resulting in very unequal numbers of plants in the different pots. In comparing the root weights of different varieties, account should be taken of the number of plants, since the roots might be expected to be rather larger in the pots where there were fewer plants. The following results were obtained :

	Root Weight per Plant.	Number of Plants per Pot.
Variety I	0·14	6
	0·16	4
	0·15	6
	0·20	4
	0·19	4
	0·07	9
Variety II	0·11	8
	0·20	5
	0·23	4
	0·21	5
	0·09	7
	0·31	3
Variety III	0·13	4
	0·15	3
	0·11	4
	0·11	4
	0·10	5
	0·15	3

This example serves only as an illustration of a statistical procedure. The data used have been specially selected from a large number of results, many of which did not exhibit this correlation.

We have seen that in the analysis of variance of a series of grouped observations the sum of squares of the deviations from the mean can be divided up into a part within groups and a part between groups. In an exactly similar way the sum of products can be divided. The correlation and regression coefficients are determined from these sums of squares and products. Three different regression coefficients and three different correlations can thus be found ; the correlation obtained from the individual observations without regard to the variety grouping is the total correlation, and the others are the within variety and between variety correlations. The root weights will be corrected for plant number according to the within class regression. This

process of splitting up the sums of squares and products is known as the analysis of covariance.

The uncorrected analysis of the root weights is as follows:

ANALYSIS OF VARIANCE.

Source of Variation.	Degrees of Freedom.	Sum of Squares.	Mean Square.
Between varieties	2	0·0135	0·0068
Within varieties	15	0·0459	0·0031
Total	17	0·0594	0·0035

The difference between the varieties is not significant. The division of the sums of squares and products into their component parts can be written in a concise analysis of covariance table.

ANALYSIS OF COVARIANCE.

Source.	Sum of Squares.		Sum of Products.	r.	b.
	Root Weight.	Plant Number.			
Between varieties	0·0135	10	+0·27	0·74	0·027
Within varieties	0·0459	40	−1·23	−0·90	−0·031
Total ..	0·0594	50	−0·96		

The correlation coefficients are respectively $\frac{0\cdot27}{\sqrt{10\times0\cdot0135}}$, $\frac{-1\cdot23}{\sqrt{40\times0\cdot0459}}$

and the regression coefficients $\frac{0\cdot27}{10}$, $\frac{-1\cdot23}{40}$.

It is interesting to note that the between varieties correlation differs widely from that within varieties.

The root weights can now be corrected according to the formula

$$\text{Corrected value} = \text{root weight} - (-0\cdot031) \times \text{number of plants.}$$

An ordinary analysis of variance could be carried out on the corrected values to determine the significance of the difference between varieties. One degree of freedom must be deducted from the within class, or error term, to allow for the fact that the value of b has been determined from the data. This analysis is only approximately correct, since the sampling errors of the regression coefficient b are involved in the corrected values of the weight. It has been shown by Fisher that the correct analysis is obtained in the following way: From the sum of squares within classes in the ordinary root weight analysis subtract

$$\frac{\text{square of product term within classes}}{\text{sum of squares for plant number within classes}}.$$

This gives $0{\cdot}0459-\frac{1{\cdot}23^2}{40}$, which is 0·0081. From the total sum of squares in the ordinary analysis, subtract

$$\frac{\text{square of total product term}}{\text{total sum of squares for plant number}}.$$

This gives $0{\cdot}0594-\frac{0{\cdot}96^2}{50}$, which is 0·0410. The varieties term is the difference 0·0420—0·0091. The corrected analysis is now:

ANALYSIS OF VARIANCE.

Source.	Degrees of Freedom.	Sum of Squares.	Mean Square.
Between varieties	2	0·0329	0·0165
Within varieties	14	0·0081	0·0006
Total	16	0·0410	

The ratio $\frac{\text{mean square between varieties}}{\text{mean square within varieties}}$ is 28. This is significant. Correcting for plant number has shown that there was a real difference between the varieties, which was cloaked at first by the variation in plant number.

TECHNICAL NOTES

SOIL SURVEY OF THE SALMON GUMS DISTRICT, WESTERN AUSTRALIA

During August, 1935, three years' field work was finalised in connection with a soil and alkali survey embracing 582,018 acres (629 locations) in the Salmon Gums district, often referred to as the "Esperance mallee lands," of Western Australia. This survey, which is probably the largest soil survey project of its type yet undertaken in Australia, was carried out by officers of the W.A. Department of Agriculture, with a surveyor of the Department of Lands and Surveys assisting in the field organisation of the work.

The Salmon Gums district is an area of relatively low rainfall, the average annual precipitation ranging from about 11 inches in the north (Beete), to 16 inches in the south (Scaddan); 60 to 65 per cent. of the rain falls during the winter months, May to October. Many light falls occur so that the average precipitation per wet day is low, the highest figure being 0.2 inch at Scaddan. This fact is important in considering the development of the soils of the district.

Detailed and systematic work on the Salmon Gums survey was undertaken after reconnaissance work in 1929 had shown that soil alkali was one of the major causes of the low and disappointing yields of wheat obtained after the area was reopened in 1922, and settlement encouraged by Agricultural Bank advances.

It has been found convenient in surveys of this nature to run classification traverses at 15 to 20 chain intervals in both cleared and virgin areas, using existing survey lines as bases. Borings to ascertain the nature of the soil profile and to determine the distribution of soil alkali, are made as required. It has been found that sampling at intervals of 10 to 15 chains is adequate in normal country, but samples are taken more frequently where bare patches, suspected as "salt" patches, occur. Normal sampling sites are chosen to be representative of the soil types encountered on the traverse, and generally samples for field examination are taken from the first and second feet of the profile.

In the course of the survey at Salmon Gums, 70,220 samples were taken from 33,446 sites. All samples were examined in a field laboratory for water soluble salts by the conductimetric method as adapted by Samuel and Teakle (Jour. Agr. W.A. Series 2, 8:219—227, 1931), while 22,267 colateral and check determinations of chloride were made using the electrometric titration procedure of Best (Jour. Agric. Sc. 19:533-540, 1929). Type samples for more

detailed work were collected from pits at 63 sites. At many of these sites deeper samplings (10 to 20 feet) were made with a 4-inch posthole digger. The mass of field and analytical data so obtained has yielded valuable evidence concerning the characteristics of the various soil types, and especially on the distribution of soluble salts in virgin and cleared areas of the same type.

The soils of the Salmon Gums district show the general characters of the soils of the "mallee" zone of Australia, described by Prescott (1931), being typically grey and brown solonised soils with calcareous subsoils. In the virgin state they carry a vegetation of mallee and sapling Eucalypts with an undergrowth of teatrees (*Melaleuca* spp.). Passing from north to south the vegetation decreases in average height, despite an increasing rainfall.

Three major groups of soils have been distinguished:—

(1) Soils having a sandy surface (1 to 12 inches deep) overlying a sandy clay subsoil with calcareous rubble.

(2) Powdery surfaced soils with rubbly subsoils of heavier texture. Finely divided calcium carbonate occurs in large quantities (up to 50 per cent.) in these soils, even in the surface layer, and is probably responsible for the powdery, single grain structure.

(3) Heavy textured soils with clay loam and clay surfaces. The subsoils are typically calcareous though less so than groups (1) and (2). Areas of these soils are characteristically uneven due to "crabholes" or "gilgai."

Soils of all three groups have been found to pass at depths below 6 or 8 feet into acid grey and brown mottled sandy clays (pH 3.5—5.0). In the southern end of the district, where the rainfall is about 16—17 inches per annum, sandy surfaced soils (the Scaddan series) occur, which have well developed columnar subsoils characteristic of the "solonetz" or structural alkali soil.

Analyses showed that a high proportion of the sampling sites in virgin areas of soils of all three groups were "high alkali" sites. Chloride, expressed as sodium chloride, was found to constitute a fairly constant proportion (65 to 85 per cent.) of the total water soluble salts, and it was also generally found that the chloride in the second foot was approximately double that in the first foot. A site was considered to be a "high alkali" site if the sodium chloride figures were:—0—12 inches: 0.15 per cent. and over; 12—24 inches: 0.30 per cent. and over; or 0—24 inches: over 0.22 per cent.

Of 2,799 sites in typical virgin areas of the *Circle Valley sand,* the most important type of the sandy surfaced soils group 1, 1570 or 56.1 per cent. were "high alkali." For the *Beete calcareous sandy loam,* of group 2, out of 1969 sites in virgin areas, 1361 or 69.1 per cent. were "high alkali," while for virgin areas of the heavy soils of group 3, 1926 out of 2402 sites or 80.0 per cent. were "high alkali."

Following clearing and cultivation, important changes in the distribution of soluble salts occur. A definite leaching occurs in sandy surfaced soils, data for the *Circle Valley sand* showing that of 2,958 sites in cleared and cultivated areas, only 4.9 per cent. were "high alkali" while no less than 73.0 per cent. had to 24 inches deep, been reduced to less than 0.13 per cent. NaCl. With soils of groups 2 and 3, changes following clearing produce a more irregular distribution of soluble salts, with still a large proportion of "high alkali" sites—40.2 per cent. for the *Beete calcareous sandy loam* and 62.0 per cent. for the group 3 soils. Upward movement of salts on many areas causes surface concentrations, and results in the formation of bare patches sterile to all plant growth, save a few halophytes. Such "bare patches' have been specially sampled and studied.

The soils of groups 2 and 3 have proved more or less unsatisfactory for wheat growing while those of group 1 are more or less satisfactory. The change in the alkali status of the latter group following clearing is the chief, though not the sole factor, responsible for this difference. On account of the relations found to exist between soil type and alkali changes after clearing, it will be realised that the recognition and mapping of the various soil types has been of equal importance with the obtaining of data on the occurrence and distribution of soil alkali.

The information gained from the soil and alkali survey, together with experience on the State Experiment Farm at Salmon Gums and throughout the district, has been used as a basis for a scheme of rehabilitation in the district. Wheat cropping will be confined to the more satisfactory soil types, while the less satisfactory soils will be utilised for grazing. Wimmera rye grass shows considerable promise on high alkali soils and it is hoped that after a number of years under pasture, an improvement in the alkali status may allow present unsatisfactory areas to be utilised for cereal cropping with more success than in the past.

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RHIZOBIAL STRAIN VARIATION IN RELATION TO THE PROBLEM OF LUCERNE SEED INOCULATION.

Recent investigations at Wisconsin, Rothamsted and Helsinki have demonstrated that strains of Rhizobium vary considerably in their capacity to benefit their host plants. In many cases a wide range in effectiveness has been indicated. The success of artificial inoculation will thus depend largely upon the selection of efficient strains of high infective virulence. Such a selection must materially enhance the possibilities of increased yield and better establishment even where the organism is already present in the soil.

A preliminary investigation of variation in the specific symbiont of lucerne has been made at the Waite Institute. Strains were isolated from lucerne grown in various parts of the Commonwealth and a comparison of their capacity to increase the yield and nitrogen content of lucerne was made in pot cultures. The plants were grown in silica sand previously treated to 1200°C. and supplied with a nitrogen-free, culture solution. In the control pots lucerne failed to grow, whereas the inoculated series showed considerable variation according to Rhizobial strain. Statistical treatment by the analysis of variance showed that the yields of lucerne differed significantly for most of the strain treatments. The mean yield per pot of plants inoculated with the most effective strain was more than six times that of the poorest strain. Nitrogen content varied from 3.18% in plants inoculated with the poorer strains to 4.26% where effective strains were employed.

The differences in nodulation were a striking feature of the experiment. Actually most nodules were produced by some of the poorer strains, but these were smaller and more widely distributed over the root systems than the nodules induced by the most effective strains. In the latter cases a few large finger-like bunches were produced close to the tap root and around the secondary roots.

The significance of strain variation in the field is the subject of further investigation. It is important to recognise that infective virulence and physiological efficiency may vary independently, and that the soil environment may influence the effectiveness of particular strains. Competition by inferior strains may be of a high order and to be effective for field inoculation, cultures that are efficient in nitrogen fixing capacity must be sufficiently virulent to overcome competition from other strains, as for instance in old cultivated areas.

Under field conditions at the Waite Institute materially increased yields were obtained at the first cutting on soil which contains the specific organism for lucerne and grows this species comparatively well. The culture employed contained a mixture of the most effective strains.

The mean yields in kilograms of dry matter per acre were as follows :—

Inoculated 214.6

Not inoculated .... 116.5 S.E. of mean difference ±7.77

Difference due to inoculation is 84.2%.

Nodules were present on the uninoculated lucerne but these were less in number than on the inoculated plants which developed large finger-like bunches in the vicinity of the tap root. A second experiment was carried out at Tintinara on the Willalooka sand types, not long cleared from mallee-broom vegetation.

Mean dry yields in kilograms of dry matter per acre, 3 months after seeding were as follows:—

Inoculated 101.66

Not inoculated .... 24.09 S.E. of mean difference ±12.5

The inoculated lucerne here yielded four times that of lucerne not so treated. In areas of this type there appears to be no doubt as to the advantage of artificial inoculation in the establishment of lucerne.

In the United States, in Canada, and in Europe where artificial seed inoculation is widely used, the introduction of a vigorous, effective strain of the specific organism produces significant response in many cases even where plants of the same cross-inoculation group have previously grown and where the organism is already present in the soil. The response to inoculation may not always be great but increases as little as 10 per cent. are considered worth while. The fact that exotic species of *Medicago* and *Trifolium* are widely distributed throughout Australia and that consequently clovers and lucerne develop nodules freely, should not be the basis for the belief that artificial inoculation with an efficient strain will not be advantageous. In all cases where nitrogen is deficient, trials of this nature are justifiable.

Legumes have proved essential as the basis for pasture improvement in South Australia, particularly as many of the soils are deficient in available nitrogen, and even the less common soils of good natural fertility tend to become deficient under the continuous growth of non-legumes. The possible advantage of artificial seed inoculation with efficient strains of *Rhizobium* in the establishment of balanced mixed pastures with lucerne and subterranean clover as leguminous elements is the subject of present investigation.

With regard to lucerne inoculation it may not be out of place to indicate here that the long cultured and highly effective strain of *Rhizobium meliloti* at present being distributed by the Western Australian Department of Agriculture has compared more than favourably with any of the freshly isolated strains so far tested.

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STRAIN VARIATION IN STRAWBERRY CLOVER (*TRIFOLIUM FRAGIFERUM* L.) AND PRAIRIE GRASS (*BROMUS UNIOLOIDES* H.B. et K.)

The value of superior strains of pasture species is now generally realised. Specialised strains of many of the more important species in Australia are already in commercial use. Notable examples are New Zealand and Victorian certified perennial rye-grass, Akaroa cocksfoot, New Zealand certified white clover and Dwalganup subterranean clover. There still remain, however, several important species of which commercial seed supplies give plants of mediocre or inferior value and these species warrant strain selection and improvement. Investigations of this character are in progress at the Waite Institute with strawberry clover and prairie grass. Both are species of recognised value, yet in each case commercial seed is of unreliable genetic constitution.

The characters sought in these two plants are those which any ideal pasture strain should possess—namely, vigour and production without the aggressive exclusion of associated species, permanence (either by virtue of true perenniality or efficient regeneration from seed), ready establishment, sward-forming characters, nutritive value, palatability, disease resistance, sufficient seed production to ensure low priced seed and adaptability to a wide range of soil and climatic conditions.

In prairie grass the most serious disabilities of the commercial strains are mediocre production, unreliability with regard to permanence and susceptibility to the smut-forming fungus *Ustilago bromivora*. Fifty seed samples, of which 29 were prairie grass and the remainder various other *Bromus* species, were available for the commencement of the *Bromus* work in 1935. After germination in seed boxes, these types were planted out on an irrigated reclaimed swamp at Wood's Point on the Murray River and also under dry-land conditions at the Waite Institute (mean annual rainfall 1925-35 = 23.98). Observations were taken throughout the year and single plants selected on the basis of performance under grazing. Seed from these plants, together with seed of new material, will be planted in 1936.

Despite the early stage of the work, many interesting points have emerged. An exceedingly wide variation was found between the 29 samples of *Bromus unioloides*. Vigour, density of tillering, erectness and relative fineness or coarseness were the most variable characters. Many strains were poorly tillered, coarse and indistinguishable from three "road-side" types collected locally and known to survive only in the absence of grazing. Several well tillered and productive forms were observed, but a test of these types under sward conditions must precede final statements as to merit. Although notes were taken

on smut occurrence, second year data derived by the use of smut-inoculated seed, will be necessary for a reliable indication of smut-resistance.

Of nine strains received as *Bromus marginatus,* five were of Australian origin and four were introduced from overseas. This species has received publicity as "Perennial Prairie Grass" and the seed has sold at a considerably higher price than that of *B. unioloides.* Hence it was surprising to find all five local types to be *Bromus unioloides H. B. et K.* The Australian grown samples included three supplied by seedsmen. All imported samples were true to name and could be distinguished readily from local material long before heading. Inquiry may show that all local samples were derived from the same source.

Of the remaining *Bromus* species, none of those sown in 1935 shows promise, with the possible exception of *B. inermis,* under Murray Swamp conditions.

The same general procedure as for the *Bromus* species was adopted with the 24 samples of strawberry clover seed available for the 1935 sowing. The main work was conducted at Wood's Point, though a few individuals of each strain were planted at the Institute. The most striking result was the marked inferiority of the five commercial types. These were all fine-leaved, short, "turf-like" and of low productivity. In contrast to this, certain strains directly derived from pastures produced a vigorous growth up to a height of seven inches, accompanied by a greater lateral spread than in the commercial types. Under the conditions at Wood's Point, seed production in the first year was not prolific in any of the strains, but in each of the commercial lines it was negligible. It is of interest that the strain known as Shearman's clover, distinguished in New South Wales (the State of its origin) by the rarity of seed production, has yielded considerable amounts of viable seed under both Waite Institute and Murray Swamp conditions. Investigations on hard seed production in strawberry clover seem to indicate that hardness may be associated directly with humidity during the period of ripening. For example, two New Zealand grown samples gave increases in germination of 17% and 4% due to scarification, whereas two Adelaide grown samples each gave increases of 82%.

As both *Bromus unioloides* and *Trifolium fragiferum* are normally self fertilised, it is hoped that within a comparatively short period, strains will be available which have proved themselves under sward conditions to be much superior to commercial types.

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PRISTHESANCUS PAPUENSIS STAL., AN "ASSASSIN" BUG.

This bug, which measures up to an inch and a quarter in length when mature, is the largest species of predaceous bug of the family *Reduviidae,* occurring in Australia. Most members of this family catch other insects and feed upon their blood which they extract by means of their short curved probosces.

P. papuensis is a tropical form, the range of which extends from Papua to northern New South Wales. It is known as the "bee-killer," as the honey bee, *Apis mellifera L.,* is sometimes captured by this bug when visiting flowers.

Illingworth (1) records this insect as an important enemy of the Linear bug *Phaenacantha australica* Kirkaldy, a pest of sugar cane in Queensland, and Summerville (2) states that at times in Queensland it destroys large numbers of the nymphal forms of the larger-horned citrus bug, *Biprorulus bibax* Breddin.

Lateral view of *Pristhesancus papuensis* (×6) (After I. W. Helmsing)

On several occasions during the past few years living adults of this bug have been kept under observation in the laboratory. They were found to mate and develop readily in breeding cages, and a generation of the bugs was bred. As little appears to have been published, some notes on their life history are worthy of record.

The eggs were laid in clusters of between 30 and 40, together with a quantity of pale, glutinous fluid which later dried, cementing the eggs to one another along their sides and firmly fixing their bases to the sides of the breeding cage. The eggs are reddish-brown in color, elongate, cylindrical, slightly curved, rounded at the base and more or less flat at the top, the operculum of the egg being surrounded by an irregularly edged flange of soft, white substance. The average length of the egg is 2.5 m.m.

The incubation period of several batches of eggs laid in the spring (October) was 15 days, while a batch laid in the autumn (April) had an incubation period of 45 days.

The time occupied in nymphal emergence varied from half to one and a half hours, from the time the operculum was first pushed off. The nymphs on hatching measure one-eighth of an inch in length, the head, thorax, eyes, legs and the base of the antennae being black in colour, while the abdomen and tips of the antennae are deep orange.

On first hatching the nymphs remained clustered round the hatching egg mass and sometimes actually punctured unhatched eggs and fed upon their contents. At this time the abdomens of the young bugs were very inconspicuous, but as feeding took place they became greatly distended.

The first stage nymphs were kept in glass jars and fed with aphids, and after seven days in summer they underwent their first moult. In their second instar, their colors were similar to those of the first stage. The bugs were then fed on ferment flies, *Drosophila* sp., and as their size increased they were provided with other and larger species of flies. Following on ferment flies, they were given metallic green tomato flies, *Lonchaea aurea* Macq., and when three weeks old, Queensland fruit flies, *Chaetodacus tyroni* Frogg, which constituted their food for the next three weeks. When six weeks old, though still immature, it was found that they were capable of catching blowflies, *Calliphora* sp., and *Lucilia* sp., and they were fed solely on these insects until they reached maturity.

The total length of the life cycle, from the deposition of eggs to the casting of the last nymphal skin, ranged from 85 to 100 days during the summer months, the nymphal period occupying from 70 to 85 days. The minimum length of life of the adult bugs was a little more than three months, but several were found to live for a period of eight months and one lived for eleven months. During the adult stage the bugs were fed solely on blowflies.

When in the vicinity of its prey, the bug extended the front pair of legs into the air, and the curved proboscis, which is normally held beneath the head, was projected forwards between the outstretched front legs. When its prey was sufficiently near, the tarsi and tibiae were suddenly partly closed back on to the femora, thus momentarily enfolding it; almost at the same moment the proboscis was inserted. Thereafter the anterior pair of legs were merely used to hold the prey in position, and the bugs were quite commonly seen walking around with their prey impaled upon the proboscis.

When in the presence of large numbers of flies, it was usual for the bugs to capture and feed on a number in succession and then to rest for several days without feeding, and during this time flies walked in close proximity to the bugs, the latter appearing to display no interest.

Adult bugs were observed to live for a period of three weeks without food, and first stage nymphs were capable of surviving two weeks starvation without apparent ill effects.

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The Australian Institute of Agricultural Science

SPECIAL NOTICE TO MEMBERS

FIRST GENERAL MEETING OF THE INSTITUTE.

Notice is hereby given that, as provided in Article 13(c) of the Articles of Association the First General Meeting of the Institute will be held at Science House, Gloucester Street, Sydney, on the 6th and 7th January, 1937.

The meeting of Council will take place in the small hall in the morning of the 6th, the General Meeting commencing at 2.30 p.m. on that day—to be held in the main hall—and continuing into the evening when the Presidential Address will be delivered. Remaining business will be concluded on the 7th, the session being scheduled to commence at 10 a.m. and terminate at 4 p.m.

Details of the business to be considered at this First General Meeting will be circulated to members at a later date.

On behalf of the Federal Council,

A. J. VASEY
Honorary Secretary.

EXECUTIVE COMMITTEE MEETING

At the July meeting of the Executive Committee consideration was given to the period of tenure of office of Branch representatives on the Federal Council, raised by the Queensland Branch. While not specifically stated in the Constitution, the opinion of the Committee was that the life of a Federal Council being ordinarily two years, Branch representatives should hold office for that period. In reference to rebate of annual subscriptions to Branches, it was indicated that the amount of the 1936 rebate would be decided by the Federal Council at its meeting in January next, but it was the intention of the Committee—in the absence of any major alterations in Institute policy—to recommend that the rebate be at least as much as that granted last year. The Hon. Secretary was directed to take steps to secure recognition of the Institute by A.N.Z.A.A.S. in order that delegates to the Council of that Association may be appointed. Several other matters also received attention.

NEW SOUTH WALES BRANCH

The sixth meeting of the Branch was held at Science House, Sydney, on June 19, when 17 members and 24 visitors were present, including Dr. Cora Hind, Dr. A. R. Callaghan, and representatives of the Forestry Commission and Irrigation Commission. The President, Dr. R. J. Noble, occupied the chair. The main business was an address on "Soil Erosion," by Mr. H. B. Matthews, B.A., Surveyor-General and Chairman of the Erosion Committee. He stated that New South Wales was the first State to take decisive action on mitigation of erosion in Australia, and also the first to bring into practical use proper methods of contour bank control on sloping farm lands. The extreme seriousness of the problem was indicated, and it was pointed out that experience in N.S.W. appeared to be no different in all the surrounding circumstances from that in other parts of the world, and the recent soil surveys in U.S.A. showed that 35 million acres in that country had already been destroyed, and out of a total of 350 million acres now under cultivation 125 millions had already lost all or most of their surface soil, while a further 100 millions were eroding seriously. The need for a stocktaking of the position as it existed here, and a plan for future operations was emphasised. Several persons contributed to the discussion which followed, including Prof. J. McDonald Holmes and Messrs. A. Morrison, R. T. McKay, F. A. Craft and G. de V. Davis.

The seventh meeting of the Branch was held on August 21, seventeen members being present. The constitution was amended in respect of clauses governing fees and office-bearers. It is now provided that fees shall become due on the first day of January, the financial year ending on December 31 each year; that the local vice-president of the Institute and representatives of the Branch on the Council of the Institute shall also be members of the Branch committee. The main business of the evening consisted of short papers presented by Mr. S. Smith-White on "Aspects of Tobacco Improvement," and by Mr. C. J. Magee on "The Possible Protein Nature of Viruses."

Mr. Smith-White stated that tobacco production in Australia reached a peak of 10,000,000 lbs. in 1931, but had since declined rapidly owing to economic, cultural and disease factors. Improvement by breeding was difficult because of the indeterminable nature of quality, the large number of factors involved, and the occurrence of blended inheritance

and parthenogenesis. The light, fine textured varieties such as Cash, Kelly and Pryor were most important in N.S.W. Selection within a variety was desirable in order to maintain the standard, and improvement was desired in yield as expressed by leaf size and number in quality as expressed by colour and texture, early maturity and drought-resistance. The benzol treatment for control of blue mould had rendered the disease problem less acute, but the breeding programme had been continued, several of the Australian forms of *Nicotiana* showing resistance to blue mould. Progress had already been made in the work involving crossing Australian species with *N. tabacum* and other forms.

Mr. Magee's remarks on viruses are referred to in the editorial article of this issue.

VICTORIAN BRANCH

The first joint meeting of the M.U.Ag.Sc., and the Victorian Branch of the A.I.A.S., was held on the 22nd May, when Dr. L. B. Bull, Chief of Division of Animal Health and Animal Nutrition, C.S.I.R., in discussing "Animal Health of Australia" stated that although the Agricultural Research Council in England came to the conclusion that the most important economic factor for the farmer was animal disease, agriculture and veterinary science were not related as closely, in Australia, as they should be. Great progress had been made in Great Britain, U.S.A., and South Africa, where large sums of money had been set aside for the study of animal health problems. Veterinary research and animal health research, continued Dr. Bull, were practically unknown until Dr. Gilruth came here in 1909. Then followed the establishment of the Veterinary Faculties at the Universities of Melbourne and Sydney, since which time animal health investigations had not looked back. Australia, fortunately, was free of the serious animal plagues experienced in other countries. With the increasing importance of the sheep and wool industry, a field of investigation opened up which had not been touched elsewhere. As a result, Australia led the world in the elucidation of sheep disease problems. Although the Animal Health Division of the C.S.I.R., was of recent origin only, much had been accomplished, particularly with regard to such problems as black disease, pulpy kidney, mycotic dermatitis, fleece rot, fly strike, botulism, pleuro pneumonia, tick fevers, mastitis, tuberculosis and contagious abortion. Dr. Bull pointed out that there was a real danger in the present attitude towards research as it was probably thought that research would solve all problems. If the tremendous amount of knowledge already available were applied, the results would be amazing.

On 26th June, Dr. W. Bryden, recently appointed Warden of the Melbourne University Union, addressed a combined gathering on "Some Aspects of the Fat Lamb Industry of New Zealand." In sheep numbers, New Zealand ranked seventh in the world. Whereas in 1880 the wool clip was the main consideration, 90 per cent. of the flocks being merino, at the present time 90 per cent. of the sheep were bred specially for meat production. Practically the whole of New Zealand was ideal for sheep raising, the well distributed rainfall giving a sustained and regular growth during the main lambing and growing period. Early maturity was an important factor. Dr. Bryden considered that the introduction of a little more merino blood into the flocks of the Dominion would greatly improve the standard of prime fat lambs for export trade. The industry, Dr. Bryden concluded, had been given a great fillip with the establishment of the Meat Board which cut down the number of meat works operating, allowing for greater efficiency, and the shipping was organised with very good results.

"Plant Breeding in the Light of Modern Genetics" was the subject of an address delivered to members by Mr. A. R. Raw on 16th July. He dealt primarily with the developments that led up to the establishment of the science of genetics, and with parallel developments in cytology which resulted in the establishment of the chromosome mechanism as furnishing the physical basis of heredity. The chromosome and the gene were considered in the light of present day knowledge, and the more recent researches and findings of Painter, Bridges, Muller et al, regarding chromosome and gene structure were dealt with at some length. The directions in which modifications of the original conception of the chromosome and the gene have taken place, were indicated also. Passing on to a discussion of the phenomenon of polyploidy, the lecturer cited various examples of natural polyploid series, and indicated their significance in regard to evolution, systematics, genetics and plant breeding. Referring to the artificial induction of polyploids and mutations, by such means as X ray, heat treatments, injuries, etc., Mr. Raw stressed the potential value of these methods to the plant breeding work of the future, and quoted the case of the artificial production of a fertile polyploid of *Pelargonium,* by the Russian breeders, as an example of the value of induced polyploidy in the production of improved varieties of agronomic value. The lecturer went on to deal with the problems of intergeneric and inter-specific hybridization, and the value of these methods for the production of new forms of plants of economic import was considered also. Special reference was made to the wheat x rye amplidiploids, and to the origin of the American *Phleum pratense.* The recent *Triticum x Agropyron* matings, which resulted in the birth of the perennial wheat was cited as an example of true intergeneric hybridization. In this regard it was pointed out that perennity was of secondary importance to winter hardiness in the production of wheat—wheat grass hybrids. The lecture concluded with a brief account of the genetic and cytological work relating to induced mutation and to intergeneric and inter-specific hybridization that has been undertaken at the State Research Farm, Werrbee.

Social News.—The annual "At Home" of the M.U.Ag.Sc., and the A.I.A.S. was held at Tudor Court on 7th August. There was an attendance of 130 members and friends who were welcomed by the Presidents of the respective bodies, Mr. A. J. Vasey and Professor S. M. Wadham. Among the guests were the Warden of the University Union (Dr. W. Bryden), the President of the Students' Representative Council (Mr. R. W. Wilmot) and the President of the Committee of University Women (Miss M. L. Smith).

QUEENSLAND BRANCH

The sixth meeting of the Branch was held in Brisbane on the 7th May, twenty members and a number of visitors (including Drs. B. T. Dickson and G. A. Currie and Messrs. C. S. Christian, T. Graves and G. F. Hill, all of the F.C.T. Branch) being present. Messrs. S. T. Blake, C. J. McKeon, T. B. Paltridge and D. R. Steindl were accepted as corporate members of the Branch. Dr. B. T. Dickson delivered an address on the development of the A.I.A.S. and compared the aims of the Institute with those of certain other professional bodies. Dr. G. A. Currie contributed an address on "The Control of Weeds," dealing with the possibilities of biological control of noxious weeds (including burrs, St. John's Wort and Lantana), with chemical methods of control and with ecological factors in weed suppression.

About fifty persons were present at the seventh meeting of the Branch, held in

Brisbane on 28th July. The visitors included Dr. B. T. Dickson and Mr. J. R. A. McMillan, of the F.C.T. Branch. Messrs. A. R. Brimblecombe and C. S. Christian were elected to corporate membership of the Branch. Dr. B. T. Dickson delivered an address on some aspects of irrigation problems in Australia and explained the steps being taken to prevent the accumulation of salts in irrigated soils. Dr. J. R. Vickery, of the C.S.I.R. Food Preservation Section, gave an account of investigations which have been carried out at the Brisbane Abattoir on the relationship between microbial spoilage of chilled beef and certain climatic factors at the point of preparation. Mr. A. F. Bell read a paper entitled "Some Aspects of the Plant Protection Services of the Bureau of Sugar Experiment Stations." The close relationship between sugar-cane plant breeding activities in Queensland and the control of pests and diseases was emphasised by the speaker.

SOUTH AUSTRALIAN BRANCH

The second general meeting for the current year was held on 25th June, with an attendance of 23 members. In addition, Mr. R. A. Sherwin, of the Tasmanian branch, was present. A letter was read from Dr. C. T. Madigan, President of the Royal Society of South Australia, requesting the appointment of a representative to attend a meeting to be convened by the Royal Society to consider in a broad way the question of improving the accommodation for existing libraries and for the meetings of the various learned societies in South Australia. Mr. H. C. Trumble was appointed to attend the meeting of representatives which was subsequently held. An address was given by Dr. I. F. Phipps, Plant Geneticist of the Waite Institute, entitled "Recent Developments in Genetics and Plant Breeding." An account of this address appears in another portion of this issue.

REPRINTS OF ARTICLES

Reprints of articles published in this Journal are available at the rates set out hereunder. The attention of authors is directed to the fact that no responsibility is taken for supply of reprints *unless* orders are forwarded with the manuscripts.

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Book Reviews

Commercial Fertilizers : Their Sources and Use, by G. H. Collings, Ph.D.

(Pp. XIV. and 356, with 66 tables and 85 illustrations: Philadelphia: P. Blakiston's Son & Co., Inc., 1934. Price, $3.25. Australian orders should be sent to Messrs. Angus & Robertson, Ltd., Sydney, N.S.W.)

This should prove a valuable text-book for teachers and students of American agricultural colleges, especially in the southern and eastern States. The author, who is associate professor of agronomy at Clemson Agricultural College, has gone to a great deal of trouble to collect the most recent information regarding the manufacturing side of the fertilizer industry. He has also brought together a mass of information regarding the fertilizer resources of the world and the general effects of the various classes of fertilizers on the most important American crops.

Some of his interpretations of experimental data are open to question, and mistakes with regard to proper names, chemical formulae and unbalanced equations are fairly common, but, on the whole, his exposition of the subject is reasonably sound. Although not so well written, it should perform the same function for the American student as the most recent edition of Hall's "Fertilizers and Manures" does for the British student.

Its chief value to the Australian reader is that it brings almost up-to-date the story of the amazing developments in the manufacture of synthetic nitrogenous and nitrophosphatic fertilizers, and gives a clear picture of the general use and results of fertilizers in the United States. Here are just a few of the high lights: At the end of 1929 there were 121 nitrogen-fixation plants in operation in 18 countries with a total production capacity of over 2 million tons. About 60% of the world's supply of combined nitrogen comes from the air. Of the nitrogen now produced by fixation from the atmosphere, about 5% is obtained by the arc process, 20% by the cyanamide process and 75% by the direct synthetic ammonia process. Out of the 8 million metric tons of fertilizers used in the United States, 5.6 million tons were applied to the soils of the Southern States—about 35% of the whole being used in connection with the cotton crop.

The book contains much useful statistical matter and many illustrations some of which, however, are not very well reproduced. Quite a good bibliography is also appended so that it ought to be on the shelves of all workers in this interesting field.

R. D. Watt.

Small Fruit Culture, by J. S. Shoemaker, Ph.D.

(Pp. XV. + 434, with 43 tables and 52 illustrations: Philadelphia: P. Blakiston's Son & Co., Inc., 1934. Price, $3.50. Australian orders should be sent to Messrs. Angus & Robertson, Ltd., Sydney, N.S.W.)

Professor Shoemaker's book is a detailed treatment of a subject on which he is personally well qualified to write; and he has been both wise and fortunate in addition in obtaining the views of a great many of his colleagues in America.

The result is a text book on the culture of the grape, strawberry, the brambles, currant, gooseberry, blueberry and cranberry which has not only a sound fundamental background, but also a pronounced practical bias making it of interest both to research workers and those engaged in practical small-fruit culture.

With the exception of the grape and its products, the production of which in Australia appears to be at least as efficient as in other countries, small fruits have received very little attention indeed from research workers and horticulturists in Australia; and the position of the small-fruit industry is far from satisfactory.

On the cultural side, virus and fungus diseases in Australia are taking a heavy toll, particularly in strawberries and the brambles; and from this point of view the reader of "Small-Fruit Culture" will find most significant the many examples of decline in the industry in America which have been arrested by control measures evolved, including the breeding or introduction of less susceptible varities. In general, one comes to the conclusion after reading this book that the varieties available for the widely varying conditions met with in Australia are really inadequate and that the small-fruit industry is in need of definite study from this point of view.

Transport difficulties in Australia constitute another major problem in small fruits, and are mainly responsible for the localized glutting which is a feature of most of our markets at the present time. References throughout the text to the development of suitable refrigerated transport facilities in the United States should be of greatest interest to Australian readers and the description of the "Frozen Pack" method of storing berry fruits (which has been successfully applied experimentally in Victorian cold storage work) is worthy of special attention.

"Small-Fruit Culture" is an excellent standard work.

FRANK M. READ

The Botany of Crop Plants, by Professor W. W. Robbins.

(Third Edition, Revised. Pp. X. + 639, with 269 figures: Philedelphia: P. Blakiston's Son & Co., Inc., 1931. Price, $4.00. Australian orders should be sent to Messrs. Angus & Robertson, Ltd., Sydney, N.S.W.)

When this book first appeared in 1917 it filled a long-felt gap in the teaching work in agricultural botany. It was not surprising that a second edition was called for in 1924 and that a third edition has now come to hand.

In recent times there has been an extension of science teaching "with an agricultural bias," leading to an increased demand for books of this nature. Hence this revised edition will be especially welcome. The author states that it is "more strictly botanical than either of the two preceding editions." This does not in any way detract from its value. Omission of certain matter dealing with the distribution and yields of certain crop plants is more than offset by the inclusion of new matter. Thus with the somewhat larger pages than were used in the previous editions, this volume runs to 639 pages.

It is unfortunate that one or two mis-statements still appear in this latest edition, as for example, that cross-pollination is the rule in the *durum* wheats. Again, whilst such a book cannot be all-inclusive, it does seem a pity that crops like bananas, coffee, pine-

apples and rubber should be entirely omitted. The inclusion of Palmae is to be commended, but it is hoped that in a future edition others of the tropical crops will be included.

The provision of literature references at the conclusion of chapters is wholly satisfactory. The illustrations are admirable and the printing and general production leave nothing to be desired.

W. L. WATERHOUSE.

Medical Mycology, by C. W. Dodge, Ph.D.

(Pp. 900 with 142 figures: St. Louis, U.S.A. The C. V. Mosby Coy., 1935. Price, $10.00.)

Bacteria are more numerous and important than the fungi in human pathology and for this reason, no doubt, medical bacteriologists rarely have had opportunities for obtaining a detailed knowledge of the fungi such as has been acquired by mycologists and and plant pathologists who have made an intensive and systematic study of this group of organisms. It is thus fitting that a mycologist, and one of the distinction of Dr. Dodge, should have prepared the first comprehensive statement on the fungous diseases of man and other mammals.

The opening chapter is concerned with the general morphology of the fungi, sexuality in the various groups, classification and affinities, aspects which are discussed in detail in the later portions of the book. A chapter on the physiology of the fungi follows and bears especially on the environmental factors relating to vegetative growth and reproduction. Methods of preparation and sterilisation of culture media are briefly discussed and two chapters are devoted to technique of isolation, use of stains and methods in microscopy. The general introductory portions close with a chapter on botanical nomenclature which receives a deservedly prominent position in the book, in which, as the author states, he has endeavoured to follow the spirit of the International Rules of Botanical Nomenclature. The remaining 16 chapters are devoted to a systematic consideration of the fungi. The organisms are discussed in detail, the position regarding nomenclature and synonymy is clearly presented and keys are provided for the recognition of genera and species.

The literature on the subject is extensive and the author has included a complete bibliography up to 1933 running into some thousands of citations—the chapter on the Trichophytoneae alone which deals with the herpes, tinea or ringworm fungi, closes with over 1000 references to published work.

Botanists and mycologists may have but a dilettantic interest in some of the clinical and pathological data which are included although approaching baldness, in some cases, may lead to a closer study of the chapter on *Malassezia* and its effects on the hair follicle. The information provided on the development of tissues and structures and on the necrotic effects which follow fungous infection are provided, however, primarily for the benefit of the botanist who may undertake a study of some of the groups in which so much purely mycological work still remains to be accomplished.

Among the Phycomycetes, the only group which contains human parasites are the Mucorales and some of the genera examined from this aspect are such well known forms as *Mucor, Absidia* and *Rhizopus*. A comparatively large number of forms occur in the Ascomycetes, and particularly in the two orders Endomycetales and Plectascales which

include the more aberrant or primitive types. Parasitic genera include those well known to plant pathologists and mycologists, e.g., *Mycoderma, Saccharomyces, Gymnoascus, Aspergillus* and *Penicillium.* The *Monilia,* however, is not taxonomically equivalent to the brown rot fungus of special significance to the orchardist. Among the Imperfecti other familiar forms are apparent in such genera as *Dematium, Acremonium, Sporotrichum, Cephalosporium, Spondylocladium, Alternaria* and *Fusarium,* while a chapter is devoted to consideration of the genus *Actinomyces* so frequently recorded in medical literature as *Nocardia, Streptothrix* or under other synonyms.

The volume is most comprehensive in character, it is well printed and contains a fine selection of well drawn illustrations and although written in the first place for the medical man, cannot fail to be of considerable interest also to mycologists and plant pathologists.

R. J. Noble.

Current Notes and News

AGRICULTURAL SCIENCE CLUB, S.A.

An outline of five short papers presented at the May meeting is given hereunder.

Dr. J. Davidson dealt with "Bioclimatic Zones of Australia." A map had been prepared to show the number of consecutive months in which the values of the Precipitation-Evaporation ratio were 0.5 or over. Areas in which summer rainfall is the dominating feature were differentiated from those characterized by winter rainfall. Temperature zones were also separated and were superimposed. Hot climates were defined as areas with a mean annual temperature above 70° F., warm temperate areas were taken as those with no month in which the mean temperature was below 43° F.; and cool temperate climates were defined as those areas having one to six months with a mean temperature below 43° F.

Mr. C. M. Donald gave a short account of investigations concerning the "Direct and Residual Effects of Superphosphate on a Sown Pasture." Fertilizer response by a pasture of subterranean clover and *Phalaris tuberosa* sown on a virgin podsol was discussed. When expressed in terms of dry matter the return per cent. of superphosphate applied, fell rapidly with increased dressing. In terms of protein the fall was much less marked. Up to a dressing of 4 cwts. superphosphate, yield of phosphorus was directly proportional to the dressing. It followed that the determination of the optimal dressing could be evaluated in the ready manner applicable to most field crops. Residual effect in the second year, from applications made in the first year, was unaffected by the magnitude of the dressing. Between a range of 0 to 4 cwt. superphosphate per acre, the return was 45 per cent.

Professor J. A. Prescott gave an account of the effect of the silica-alumina ratio of clays on the physical properties and base exchange relationships of the soils from which they had been derived. A series of red basaltic soils from eastern Australia were discussed and the results regarding exchange capacity were shown to fall into line with those obtained by recent workers in the United States. High ratios were associated with high values for moisture equivalent and exchange capacity. The difficulties recently experienced by the soil surveyors in the Murrumbidgee Irrigation Areas in correlating

texture classes with those of the Murray River surveys would no doubt be found eventually to be related to differences in the composition of the clay fraction.

Mr. T. H. Strong discussed preliminary experiments that had been made to investigate the significance of strain variability in legume seed inoculation. Strains of the nodule producing organism of lucerne, *Rhizobium meliloti,* had been isolated from various centres in Australia and a comparison had been made of their physiologic efficiency on the basis of yields of dry matter when grown in nitrogen-free sand. On the basis of statistical comparison, four groups of strains were established in accordance with their respective levels of physiologic efficiency. Striking differences in nodulation occurred. The agricultural significance of this variation was pointed out and the importance of infective virulence in overcoming inferior but aggressive strains under field conditions was also stressed.

Mr. H. C. Trumble demonstrated a map showing the length of the effective rain period in South Australia. This had been obtained from the monthly relation between rainfall and free water surface evaporation. Isolines for 9, 7.5, 6 and 5 months had been constructed from the rainfall for 206 stations and the evaporation, calculated from saturation deficiency, for 24 stations. Each isoline was found to possess material agricultural significance. It was suggested that the seasonal or influential rainfall, as determined by the amount of rain falling within the effective period for each centre was a more satisfactory criterion for agricultural purposes than the total annual rainfall, or the rain falling within an arbitrarily chosen period, as e.g., April to October.

At the July meeting, Dr. A. H. K. Petrie gave an account of a study that he had made in collaboration with Professor J. G. Wood on protein-amino-acid equilibria in plants. This study represented a new approach to the problems of nitrogen metabolism and was the first attempt that had been made to apply modern experimental methods to the quantitative investigation of the chemical processes concerned. Uniform plants were placed under conditions of constant low light intensity, with constant temperature and water supply. These were supplied with different amounts of ammonium salts. Over a period of three or four days, plants were removed and the leaves investigated. Measurements were made of the contents of the various nitrogen compounds, water, etc., $_{p}H$ of the sap and respiration rate.

Fitting regression equations to the data as a whole, it was found that approximately 90% of the variance in the protein-nitrogen content was accounted for by variations in the content of amino acids and water, and in the sap $_{p}H$. It was concluded that the data referred to a moving dynamic equilibrium. From the regression equations it was clear that reduction in water content brought about protein hydrolysis and explanations for this were given.

RECENT HONOURS

Mr. E. R. Hudson, Superintendent of Extension Services in the Tasmanian Department of Agriculture, has been appointed Professor of Agriculture and Director of the Canterbury Agricultural College, Lincoln, New Zealand, where his duties will commence on November 1. Returning to New Zealand from the War in 1917, Mr. Hudson took up his work in agricultural education with the New Zealand Education Department. In 1920, he commenced his course for the B.Sc. and B.Agr. degrees at Canterbury College and later at Lincoln, and in 1923 was the recipient of both degrees. He spent some time as Agricultural Science Master in Wanganui, whence he was appointed as Lecturer in

Agriculture and Senior Science Lecturer to the Dunedin Training College. Early in 1928, Mr. Hudson came to Tasmania as Superintendent of the Extension Service and during the last eight years he has been responsible for the farm advisory and instructional work in agriculture, the handling of the technical side of Rural Rehabilitation, Soldier Settlement and so on. As chief administrative officer in the North, his advice in a consultative capacity has proved invaluable to his fellow officers. Mr. Hudson was the first president of the Tasmanian Branch of the A.I.A.S. and is now the vice-president and member of the Council. By his departure the Branch loses one of its strongest members. He will leave Tasmania with the best wishes of all his friends and colleagues, but there is a distinct feeling of regret in the Department and amongst the farmers that his valuable services are being lost to the State.

Dr. E. J. Underwood, research officer in animal nutrition in the Western Australian Department of Agriculture has been awarded a Commonwealth Fund Service Fellowship which provides for a period of two years' research and travel in the United States of America. Since his return to Western Australia in 1931, after studying for two years at Cambridge where he gained the Ph.D. degree, Dr. Underwood has been engaged in research work in connection with animal nutrition problems in that State. His most important work has been the investigation—in collaboration with Mr. J. F. Filmer—of enzootic marasmus (Wasting Disease) of cattle and sheep in the Denmark district, and botulism (Toxic Paralysis) of sheep in the wheat belt. The enzootic marasmus work has resulted in the effective control of this disease and, at the same time, has made a valuable contribution in the field of mineral metabolism by demonstrating that minute quantities of cobalt salts will cure and prevent the disease. Dr. Underwood proposes to continue the study of the functions of cobalt in animal metabolism, and will commence his work abroad at the University of Wisconsin. He expects to leave Australia in October, and will be accompanied by his wife and child.

The Ph.D. degree was conferred on Mr. J. G. Churchward M.Sc. by the University of Minnesota in June last. This honour was the outcome of a brilliant course of studies at Minnesota during his tenure of the Walter & Eliza Hall Research Fellowship, 1931-1933. Subsequent to graduating from the Faculty of Agriculture at Sydney in 1927, Dr. Churchward filled a number of teaching appointments in agricultural high schools, and at present is Assistant Lecturer in plant pathology and genetics at Sydney University. The thesis for the Ph.D. degree dealt principally with the inheritance of resistance to bunt, flagsmut and rust, and other characters in a wheat cross—Federation X Hope.

Mr. H. J. Hynes, M.Sc., B.Sc.Agr., Senior Assistant Biologist in the N.S.W. Department of Agriculture, was admitted early this month to the degree of Doctor of Science in Agriculture at Sydney University. The title of the thesis was: "Studies on root-rot diseases of cereals, with special reference to those caused by *Helminthosporium* spp., *Rhizoctonia solani* and *Ophiobolus graminis*."

RETIREMENT OF PROFESSOR PERKINS.

At the Annual Speech Day of Roseworthy Agricultural College, the following tribute to Professor Perkins—who retired from the Directorship of Agriculture in South Australia some few months ago—was paid by the Principal, Dr. A. R. Callaghan:—

"As this is probably the last occasion upon which Professor Perkins will attend a function of this nature in his official capacity as Director of Agriculture, I, as the present Principal of the Institution to which he has been devoted and loyal for the last forty-four years, would be guilty of a grave omission if I failed to make reference to his very great and unprecedented influence on the development of the College. For ten years, from 1904 to 1914, he was Principal, and for twelve years previous to that he was on the teaching staff, so that for twenty-two years he was intimately concerned with its welfare. During that time records and publications show that he worked unceasingly in the interests of those he taught, and in the interests of primary production generally. At the outset, wine-making and viticulture demanded his full attention and I am positive no man has done more for the wine trade and viticultural interests of South Australia than Professor Perkins per medium of direct advice, and per medium of the many capable and thoroughly trained students who passed through his hands. As Principal, his experience became more diverse and with the logical, analytical, patient and scholarly mind, that is still so alert, he exploited new fields, eventually to establish himself as a leading authority on most things pertaining to agriculture. All this time the College grew and prospered, fresh fields of work and investigation were undertaken and the College training became more and more complete. It would be impossible for me to attempt even a resume of what Professor Perkins achieved for the College during his term as Principal; suffice it to say that whatever he did was done earnestly, with a subtle insight for the future. No more fitting emblem of this trait of his can be found than in the wonderful heritage of trees and greenery he left, which make our College the oasis it is, refreshing and restful. Beside him in his efforts he had a co-worker of the first order, for Mrs. Perkins, I know from good authority, entered whole-heartedly and unselfishly into the spirit of true service his position demanded. I am sure Professor Perkins will be feeling restive and apprehensive if I continue much longer in this strain, but his personal help, advice, assistance and friendship have meant so much to me since I came to South Australia that I am determined to thank him here and now for his unfailing courtesy, his substantial help and well-considered advice. Although retiring officially I am sure he will continue to take a lively interest in the agriculture of the State and in the College in particular. Just as I shall miss his official help, so, I am sure, the Council will miss his mature and well-trained judgment and there is nothing would please me more if ways and means were provided for him to continue as a member of the Governing Council. May I, Sir, on behalf of the College, wish you and your wife good health, long life and every happiness."

NEW POST-GRADUATE SCHOLARSHIPS AT SYDNEY.

Under the will of the late Dr. Pawlett of Cremorne, further post-graduate scholarships in agriculture are now available. The income from the residue of his estate, which amounts to at least £800 p.a. is to be utilised "for the purpose of encouraging and promoting the scientific study of agriculture in connection with the University by the founding of a research or travelling scholarship or scholarships in agriculture to be called the Thomas Lawrence Pawlett Scholarship."

Mr. W. M. Holman, B.Sc.Agr., and Mr. J. M. Vincent, B.Sc.Agr., were each awarded a Pawlett Scholarship this month, and have departed for London where they will undertake courses of study at the Imperial College of Science and Technology.

Mr. Holman, since he graduated with honours in 1935 has been employed at Sydney University as a demonstrator in agricultural chemistry, and this will be his main branch of study whilst abroad. He recently compiled a paper on the solubility of phosphates in the soil, which the Royal Society of New South Wales has accepted for publication.

Mr. Vincent graduated with honours in 1933, and was engaged as a lecturer in nature studies and biology at the Teachers' Training College, Sydney. At the Imperial College of Science he will undertake courses in bacteriology and bio-chemistry.

Another large bequest (The Garland Estate) should also materialise at an early date. The details are not yet known but Vet. Science and Forestry within the University of Sydney are to benefit as well as Agriculture.

EMPIRE JOURNAL OF EXPERIMENTAL AGRICULTURE

Sir John Russell, on behalf of the Board of the Empire Journal of Experimental Agriculture, recently communicated with Professor A. E. V. Richardson asking whether it would be possible to increase the number of subscribers from Australia. The attention of readers is therefore directed to the need for increasing the circulation of this valued publication, and it may be stated that Sir John Russell and his colleagues are financially responsible for the success of the Journal which has been published quarterly for the last three years.

This periodical is designed to deal particularly with problems relating to crops and animal husbandry, and the results of controlled experimental work in the field arising from scientific investigation. The past numbers of the Journal have dealt with a wide variety of problems on pasture production, inheritance of wool, meat and milk, on livestock, cereal and soil problems, etc., from contributors in various parts of tne Empire.

The Journal is published four times a year, and the subscription is 20/- sterling, post free. The Oxford University Press, Warwick Square, London, E.C4, are the publishers.

Personal Notes

NEW SOUTH WALES.

Mr. R. E. Dwyer, Economic Botanist, Rabaul, and who recently was also Acting Director of Agriculture of the Territory of New Guinea, visited N.S.W. in July-August during his biennial leave.

Mr. F. T. Bowman, Ben Fuller Travelling Scholar, has been granted the M.Sc. degree from the University of California. This followed the presentation of a thesis on the effect of time of thinning on leaf development in fruit trees, and the completion with high grades of several advanced courses of study.

VICTORIA.

Sir David Rivett, who is abroad at present, will attend a meeting of the British Commonwealth Scientific Conference in London during September. It is intended to discuss the co-ordination of the organisation of several branches of scientific research. While abroad Sir David intends to investigate also the production of oil from coal.

Miss Ann Nicholls left for Toronto during August, where she will study physiography under Griffith-Taylor.

Mr. F. de Castella, Viticulturist to the Victorian Department of Agriculture for more than 25 years, has retired.

Further letters from Mr. H. C. Forster, who is at the Iowa State College, indicate that he took advantage of the University vacation to attend a summer school course of lectures by Prof. R. A. Fisher, with whom he had the opportunity to discuss our special problems.

SOUTH AUSTRALIA.

Mr. T. J. Marshall, of the Soils Division C.S.I.R., has been awarded a Senior Research Studentship by the Trustees of the Council. He left for America on 16th July and will engage in post-graduate studies of soil survey methods at the University of California.

Dr. A. H. K. Petrie has been granted a period of study leave by the University of Adelaide and left for Cambridge on 30th July.

Mr. L. J. Dumbleton, B.Sc., Assistant Entomologist of the Cawthron Institute, Nelson, New Zealand, has commenced a post-graduate course at the Waite Institute on climatological work in relation to insects.

Dr. L. Key, from London, and Mr. A. L. Tonnoir, from Canberra, were at the Waite Institute in June in order to discuss questions relating to the migration of grasshoppers.

QUEENSLAND.

Mr. Robert Veitch, Chief Entomologist in the State Department of Agriculture and Stock, has been appointed also Director of Research.

Mr. L. F. Mandelson, formerly Pathologist in the Department of Agriculture and Stock, has been appointed Agricultural Research Officer.

Mr. R. B. Morwood has taken charge of the recently opened Plant Pathological Field Station at Toowoomba, which will serve the Darling Downs and Granite Belt, respectively the State's chief wheat and deciduous fruit-growing areas.

TASMANIA.

Mr. P. H. Thomas, Chief Horticulturist of the Department of Agriculture, who is taking advantage of his long service leave to visit America, left Tasmania on 25th July. He will make an investigation of the fruit activities in California, Oregon and British Columbia, the Government having provided him with certain facilities. He expects to be away till November 1st.

Mr. R. H. Bevin attended the Conference on Standardisation of Wearing Parts of Agricultural Machinery, held in Melbourne on 30th June.

Errata

The following corrections should be made to articles appearing in Vol. 2, No. 2, June, 1936, of this Journal:

On page 50, line 11, read " eighties " instead of " part ".

On page 71, line 15, the formula should read as follows:

$$s=\sqrt{\frac{S(x-x)^2+S(x'-\bar{x}')^2}{2n-2}}$$

On page 74, the formula immediately under the heading " Sum of Squares " should read as follows:

$$k S(\bar{x}_r-\bar{x})^2$$

and that immediately under the heading " Mean Square or Variance " as:

$$\frac{k S(x_r-\bar{x})^2}{p-1}$$